SUSCEPTIBILITY OF LYGUS BUG POPULATIONS IN ARIZONA TO ACEPHATE (ORTHENE®) AND BIFENTHRIN (CAPTURE®) WITH RELATED CONTRASTS OF OTHER INSECTICIDES

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Abstract

Adult lygus bugs, *Lygus hesperus* (Knight), were collected from alfalfa fields in 11 different cotton-producing areas of Arizona. A standardized, glass vial method was used to estimate susceptibility of the collected populations to the organophosphate insecticide, acephate (Orthene®), and the pyrethroid, bifen-thrin (Capture®). Overall, lygus from throughout the state were significantly less susceptible to acephate and bifenthrin in 1995, than in 1994. Resistance of lygus to acephate continues to be widespread, and intense, but not uniform in Arizona. In 1995, all populations possessed individuals capable of surviving exposure to vial treatments of 10,000 (g/ml acephate. Lygus bugs from Safford and Maricopa represented the most and least susceptible populations, respectively, to both acephate and bifenthrin. These two popula-tions were tested for susceptibility to the following nine other insecticides: aldicarb (Temik®), dimethoate (Gowan Dimethoate E267®), endosulfan (Gowan Endosulfan 3EC®), imidacloprid (Admire 2F®), malathion (Gowan Malathion 8®), methamidophos (Monitor 4®), methomyl (Lannate LV®), oxamyl (Vydate 3.77L®), and oxydemeton-methyl (Metasystox-R SC®). The Maricopa population was significantly less susceptible to six of these insecticides. Our findings support the hypothesis that the intensive use of pyrethroid and organophosphate insecticides for whitefly control in cotton has selected for resistance in lygus. This result portends increased problems with lygus control in the future, points to the need for developing new tools for controlling lygus bugs in Arizona cotton, and underscores the urgent need to find alternatives to the current heavy reliance on insecticides for managing whiteflies in cotton.

Introduction

Lygus bugs are very significant pests of cotton in the desert Southwest (Wene and Sheets 1994). Though lygus populations in Arizona consist of a complex of four different species, by far the most common in the cotton-growing areas is *Lygus hesperus.* Cotton fields can be invaded by this pest between May and September, when great numbers migrate from nearby crops, such as alfalfa and safflower (Seveacherian and Stern 1974, Mueller and Stern 1974). Feeding by lygus reduces cotton yields due to shedding of immature squares and damage to bolls (Mauney and Henneberry 1978, 1984).

In Arizona cotton, the severity of invasions by lygus has varied widely over recent years. Pest managers must be vigilant in monitoring for lygus and they routinely are faced with making decisions as to whether insecticide treatments are economically warranted for this pest. Unnecessary application of insecticides is not only costly but increases the possibility of secondary pest outbreaks (Leigh et al. 1970). Yet, inadequate scouting or delays of required treatments for lygus can result in severe yield losses.

Resistance of lygus to insecticides has long been a concern of cotton pest managers. In California, Leigh reported increased resistance of lygus to organophosphate and carbamate insecticides at locations with greatest insecticide use (Leigh et al. 1976). We continue to use many of these same organophosphates and carbamates to control lygus in Arizona. More recently, Knabke and Staetz (1991) reported substantial reductions in susceptibility of specific Arizona populations of lygus to pyrethroids, relative to populations from the Imperial Valley of California.

While resistance can often be a potential cause for control failures, many factors other than resistance can result in inadequate performance of pesticides, especially with highly mobile pests like lygus. In particular, a high rate of immigration of lygus from refuges into cotton can provide the appearances of insecticide failure in the absence of resistance. It is only by testing pests with precision bioassays in the laboratory that we can determine whether resistance is a factor at any particular location where pesticide performance is in question.

In 1993, severe lygus infestations were experienced throughout much of the Arizona cotton crop. At that time some growers in Maricopa, Pinal and Pima counties reported inadequate performance of lygus treatments. The information presented herein was developed in response to those concerns. We summarize investigations, begun in 1994 and continued in 1995, of the susceptibility of Arizona lygus populations to the pyrethroid insecticide, bifenthrin (Capture®) and the organophosphate, acephate (Orthene®). We broadened our studies in 1995 to include evaluations of other insecticides used for control of lygus. In doing so, we selected two populations from our statewide resistance monitoring, one least and one most susceptible to bifenthrin and acephate, and tested the susceptibility of these populations to nine other insecticides. This information advances our knowledge of what resistances are limiting the effectiveness of insecticides used against lygus in Arizona and allows us to take steps to proactively manage such problems.

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Materials and Methods

Collection of Lygus

Using sweep nets, approximately 400-600 adult lygus bugs were collected from each field location. Bugs were emptied from the sweep nets into lunch-size paper bags in which a base of alfalfa cuttings had first been placed. These bags were then placed over ice within ice chests, and transported to the laboratory in Tucson. In the laboratory, most lygus were tested the same day of collection. When necessary they were held for 24-48 hours at 15-20°C, prior to being tested. Lygus populations were sampled from Buckeye (3 locations), Casa Grande (3 locations), Cochise County (2 locations), Gila Bend (3 locations), Gilbert (3 locations), Maricopa (3 locations), Marana (3 locations), Paloma (3 locations), Parker (3 locations), Safford (3 locations) and Yuma (3 locations), Arizona. In all but one case, collections were made from alfalfa fields located adjacent to cotton. The Maricopa 2 sample was collected from cotton.

Bioassay Method

We used the glass vial bioassay technique described by Knabke and Staetz (1991). Modifications to this technique included: drying treated vials on a commercial hot dog warmer; covering infested vials with dialysis membrane, instead of vial screw caps; and the elimination of carbon dioxide for anesthetizing bugs to facilitate handling.

Standard 20 ml, screw-cap scintillation vials were used. These were treated with solutions of insecticide or, for controls, acetone. A volume of 0.5 ml of solution was placed in each vial. Vials were immediately placed on the hot dog warmer, operating at room temperature, and slowly rotated until the solvent evaporated. This provided thorough coverage of insecticide on the inner surface of the vials.

Solutions were made using technical insecticide, on the basis of weight of active ingredient insecticide to total volume of solution. For the statewide monitoring, acephate concentrations used were: 0 (control), 1,000 and 10,000 (g/ml. Bifenthrin concentrations were: 0, 10 and 100 (g/ml. Acephate solutions were prepared each day that bioassays were conducted and were used within 24 hours. Bifenthrin stock solutions were stored at 3°C for up to 4 weeks after mixing. From the stock, bifenthrin dilutions were prepared each day that vials were treated. Bifenthrin-treated vials were stored at 3°C for up to 2 weeks before being used.

Contrasts of susceptibility of Maricopa and Safford lygus bugs were conducted with the following formulated insecticides: aldicarb (Temik®), dimethoate (Gowan Dimethoate E267®), endosulfan (Gowan Endosulfan 3EC®), imidacloprid (Admire 2F®), malathion (Gowan Malathion 8®), methamidophos (Monitor 4®), methomyl (Lannate LV®), oxamyl (Vydate 3.77L®), and oxydemeton-methyl (Metasystox-R SC®). Each insecticide was evaluated against both populations using 5-6 concentrations ranging from 0.1 to 10,000 μg/ml. A total of 8-10 replications were conducted of each concentration tested. All concentrations were computed on the basis of weight of active ingredient to total volume of solution. Imidacloprid solutions were prepared with distilled water, and imidacloprid-treated vials were rotated for 24 hours to dry. Acetone was used as the diluent for the other 8 insecticides and vials treated with these solutions were rotated for a minimum of 10 minutes but no more than one hour. Insecticide-treated vials were used for bioassays on the same day they were prepared, except with imidacloprid. Imidacloprid-treated vials were stored in darkness for up to 2 weeks before being used.

Field-collected lygus were held in one-quart plastic containers, with hinged snap lids. From these containers groups of five adult lygus were aspirated into each bioassay vial. Infested vial were closed with 1"x 1" squares of dialysis membrane secured with a #8 rubber band. Prepared bioassay vials were then held for 3 hours in an incubator, maintained at 27°C, after which mortality was recorded. Individuals unable to exhibit repetitive movement of locomotory appendages were scored as dead. Those unable to walk one body length but exhibiting repetitive movement, were scored as moribund. Live individuals walked at least one body length. Mortality values reported herein represent only the individuals scored as dead. Inclusion of moribund individuals in mortality estimates did not alter our results appreciably. Statistical significance of differences between the populations evaluated was determined by ANOVA of mean mortality values, transformed with arcsin $\sqrt{x}$.

Results and Discussion

Statewide Surveys of Susceptibility to Bifenthrin and Acephate

Susceptibility of lygus populations from throughout Arizona is illustrated in Fig. 1a-b (bifenthrin) and Fig. 2a-b (acephate). Control mortality was consistently below 10%. In 1995, susceptibility of lygus bugs to bifenthrin varied widely within the state. Populations most susceptible to bifenthrin originated from Cochise County, Safford and Yuma. The populations least susceptible to bifenthrin represented the major low desert cotton-growing areas of Buckeye, Paloma and Parker. Most populations had individuals that survived exposure to treatments of 100 (g/ml bifenthrin (Fig. 1b). However, this treatment yielded no survivors of the Cochise County and Safford populations.

Resistance of lygus to acephate was widespread but not uniform throughout the cotton-producing areas of Arizona. Populations most susceptible to acephate originated from Cochise County and Safford. Populations least susceptible to acephate were found in Gila Bend, Marana, and Parker. Most populations had individuals that survived exposure to

treatments of 10,000 (g/ml acephate (Fig. 2b). However, this treatment resulted in no survivors of the Cochise County #2 population. The extreme variation observed in susceptibility of lygus within and between the major cotton-growing areas illustrated that generalizations regarding susceptibility of populations do not apply statewide. Insecticides that work very well in Safford, Yuma and Cochise County are likely to be less effective against populations in Parker, Marana and Gila Bend. Area-specific resistance monitoring is necessary to interpret such differences.

1994 - 1995 Contrast of Statewide Surveys of Susceptibility

Figures 3a-b contrast locations from which we obtained data regarding lygus susceptibility in both 1994 and 1995. Lygus from throughout the state were significantly less susceptible to bifenthrin in 1995 than in 1994 (Fig. 3a). The populations most susceptible to bifenthrin in 1994 were from Yuma, Safford, Parker and Marana. For bifenthrin, the only relatively susceptible populations observed in 1995 were from Safford. The least susceptible populations in 1994 were from Casa Grande; survivorship of 100 (g/ml bifenthrin treatments ranged from 6-38%. In 1995, the least susceptible populations came from the Parker area. These lygus exhibited 82-100% survivorship of 100 (g/ml bifenthrin treatments.

Temporal changes were also observed in statewide susceptibility of lygus to acephate (Fig. 3b); lygus were significantly less susceptible to acephate in 1995, than in 1994. In 1995, the Safford collections were the most susceptible. Buckeye, Gilbert, Parker and Marana populations were the least susceptible to acephate, with survivorship of 10,000 μg/ml treatments ranging from 52-100%. The two Marana populations exhibited an extreme reduction in susceptibility to acephate from 1994 (no survivors of 10,000 μg/ml acephate treatments) to 1995 (86-100% survivorship).

These substantial changes in susceptibility to bifenthrin and acephate support the hypothesis that resistance problems in Arizona lygus are increasing due to the intensive insecticide use against whiteflies in cotton. This underscores the importance of the multi-agency efforts underway in Arizona to reduce in-secticides use and to develop alternative non-chemical controls for managing whiteflies.

Contrasts of Maricopa and Safford Populations

Figures 4a-b illustrate significant regional differences in lygus susceptibility to a broad range of insecticides. The Maricopa population, tested because of its low susceptibility to acephate and bifenthrin, exhibited substantially reduced susceptibility to 6 of 9 other insecticides, relative to a Safford population (Figs. 5a-i). The Safford population was selected due to its com-paratively high susceptibility to acephate and bifenthrin.

Our results indicated the presence in Arizona of lygus resistances to aldicarb, dimethoate, imidacloprid, malathion, methomyl and oxamyl (Figs. 5a-i). These conclusions should be verified by evaluations of additional populations. Nonetheless, the large differences observed in susceptibility to recommended insecticides points to the essential role served by ongoing resistance monitoring, in order to help growers to avoid using the less effective products for lygus control.

Conclusions

Our findings indicate that lygus bugs in Arizona cotton are becoming increasingly resistant to insecticides. It is likely that this condition is fostered by insecticides applied to suppress the severe whitefly infestations that have developed in recent years. That is, resistance in lygus bugs is likely a collateral impact of whitefly management. Therefore, chemical control and resistance management programs for both of these pests need to be developed jointly and harmonized. Foremost in this regard is the registration of new growth regulators for whitefly control and establishment of the 1996 Arizona whitefly resistance management strategy. These topics are discussed else-where in this volume.

Finally, though it is prohibitively expensive to monitor susceptibility to insecticides on a farm-by-farm basis, much information can be provided to growers by continuing routine surveys of resistance, coupled with testing of populations with which growers are experiencing control problems. The University of Arizona's Extension Arthropod Resistance Management Laboratory will continue to work with growers, PCA's and chemical producers in Arizona in pursuit of these objectives.

Acknowledgments

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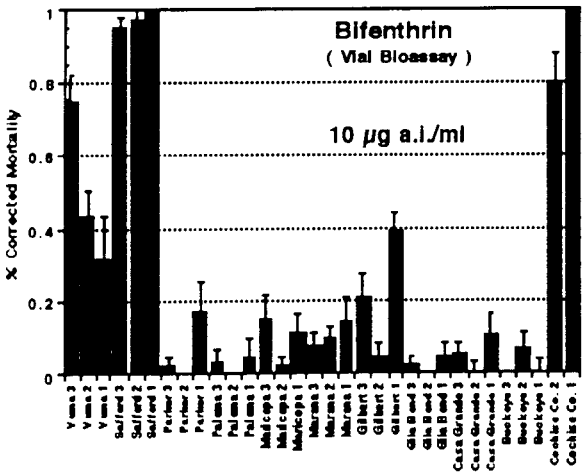

Figure 1a. Mortality of Arizona lygus bugs in 1995 vial bioassay treatments of 10 μg/ml bifenthrin.

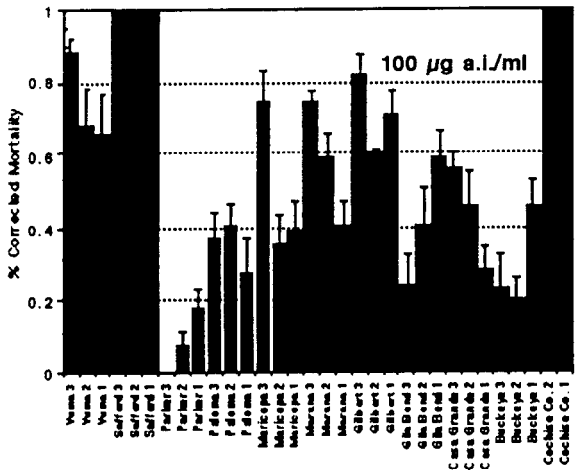

Figure 1b. Mortality of Arizona lygus bugs in 1995 vial bioassay treatments of 100 μg/ml bifenthrin.

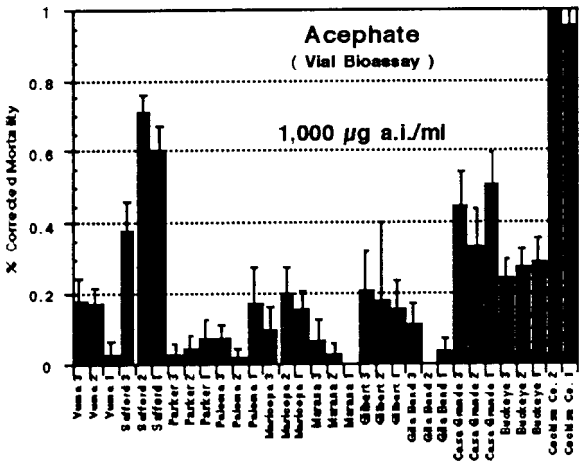

Figure 2a. Mortality of Arizona lygus bugs in 1995 vial bioassay treatments of 1,000 μg/ml acephate.

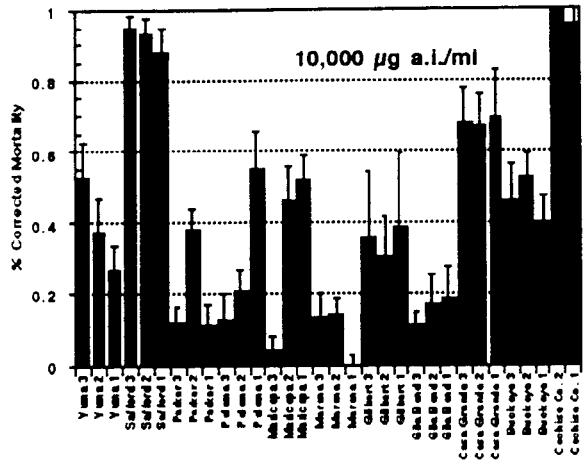

Figure 2b. Mortality of Arizona lygus bugs in 1995 vial bioassay treatments of 10,000 µg/ml acephate.

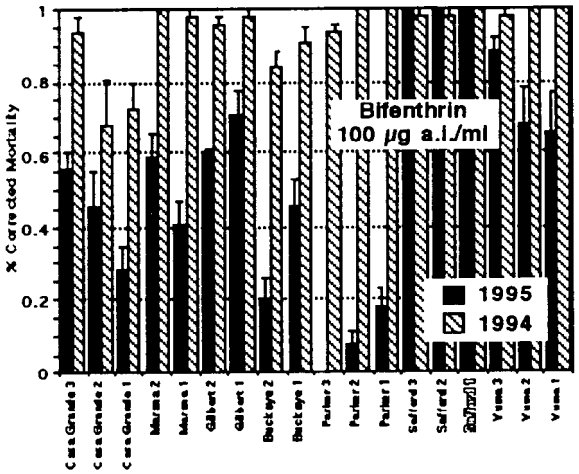

Figure 3a. Changes in Arizona lygus bug susceptibility from 1994 to 1995 as depicted by vial bioassay mortality in treatments of 100 µg/ml bifenthrin.

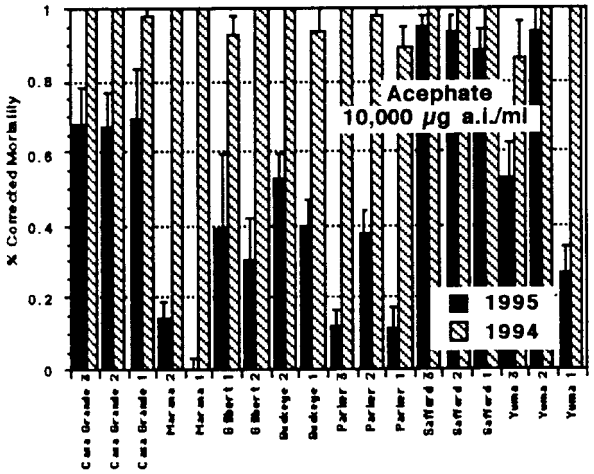

Figure 3b. Changes in Arizona lygus bug susceptibility from 1994 to 1995 as depicted by vial bioassay mortality in treatments of 10,000 µg/ml acephate.

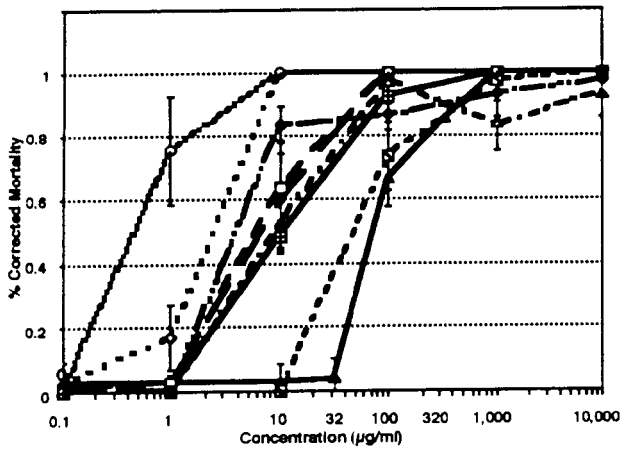

Figure 4a. Susceptibility of the Safford 1 population of lygus bugs to nine insecticides as depicted by mortality observed in vial bioassays conducted in 1995.

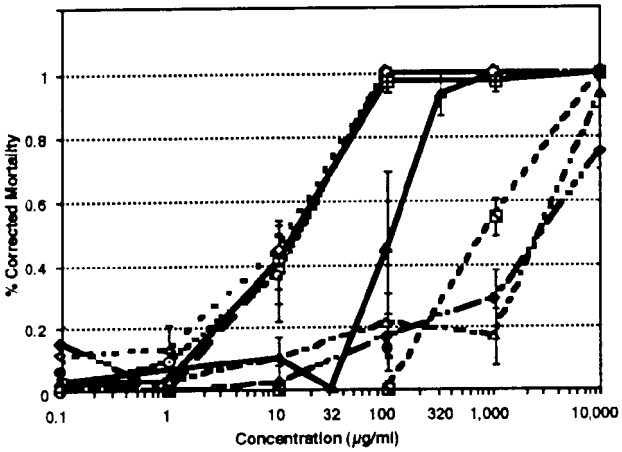

Figure 4b. Susceptibility of the Maricopa 1 population of lygus bugs to nine insecticides as depicted by mortality observed in vial bioassays conducted in 1995.

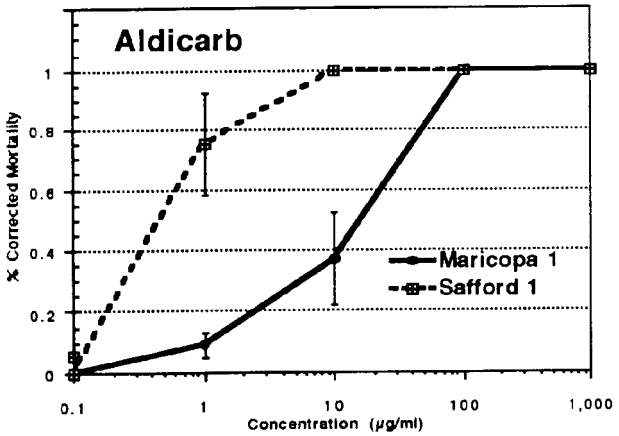

Figure 5a. Susceptibility of the Maricopa 1 and Safford 1 populations of lygus bugs to aldicarb, as depicted by mortality observed in vial bioassays.

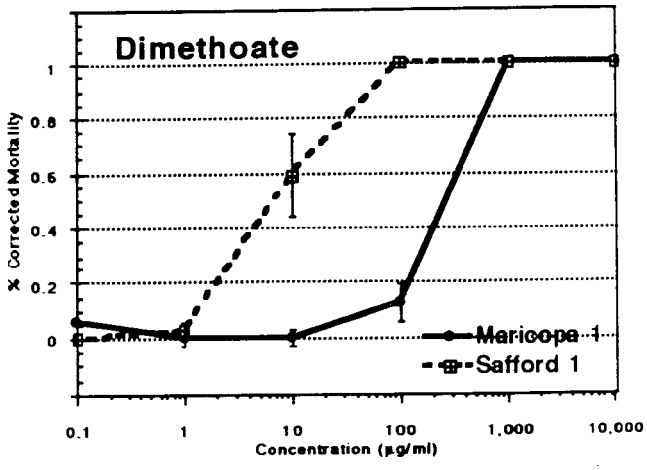

Figure 5b. Susceptibility of the Maricopa 1 and Safford 1 populations of lygus bugs to dimethoate, as depicted by mortality observed in vial bioassays.

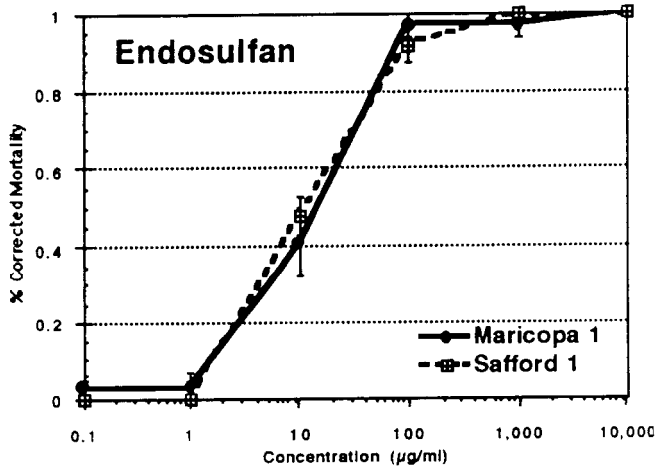

Figure 5c. Susceptibility of the Maricopa 1 and Safford 1 populations of lygus bugs to endosulfan, as depicted by mortality observed in vial bioassays.

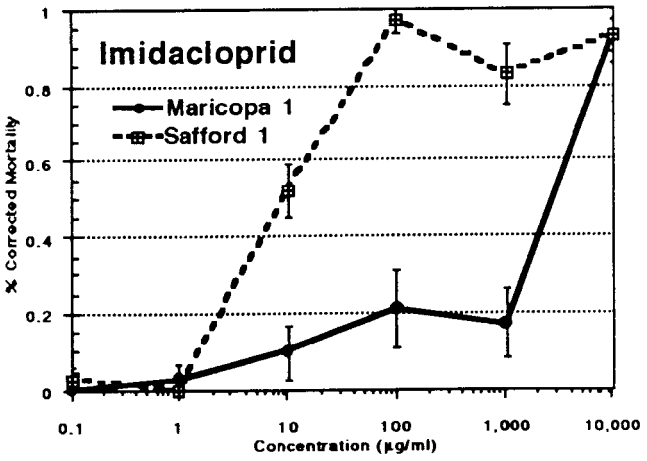

Figure 5d. Susceptibility of the Maricopa 1 and Safford 1 populations of lygus bugs to imidacloprid, as depicted by mortality observed in vial bioassays.

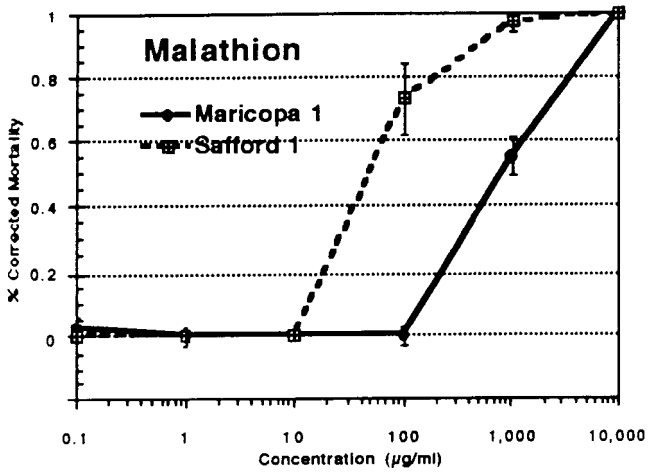

Figure 5e. Susceptibility of the Maricopa 1 and Safford 1 populations of lygus bugs to malathion, as depicted by mortality observed in vial bioassays.

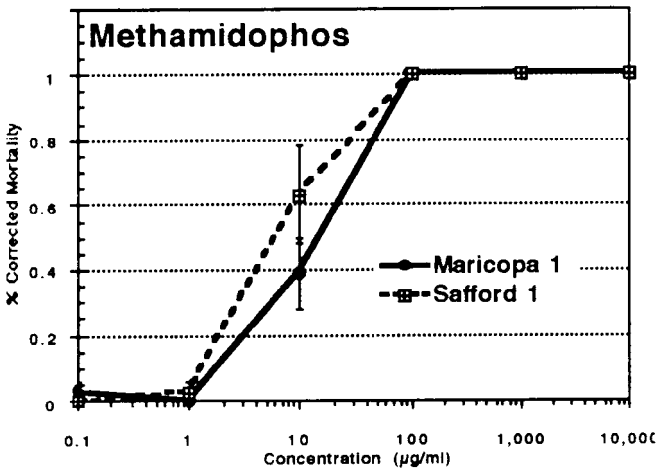

Figure 5f. Susceptibility of the Maricopa 1 and Safford 1 populations of lygus bugs to methamidophos, as depicted by mortality observed in vial bioassays.

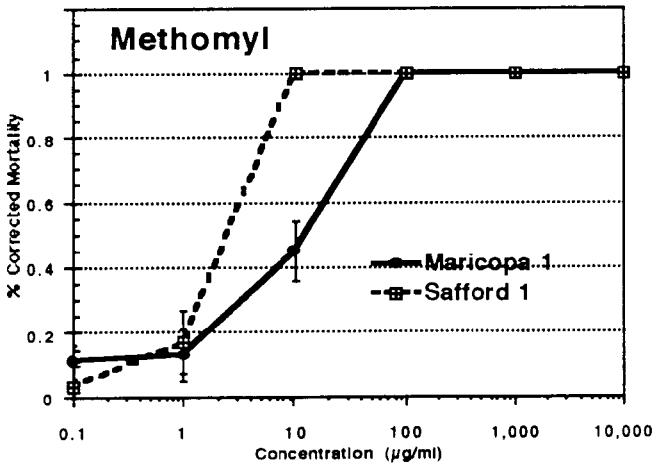

Figure 5g. Susceptibility of the Maricopa 1 and Safford 1 populations of lygus bugs to methomyl, as depicted by mortality observed in vial bioassays.

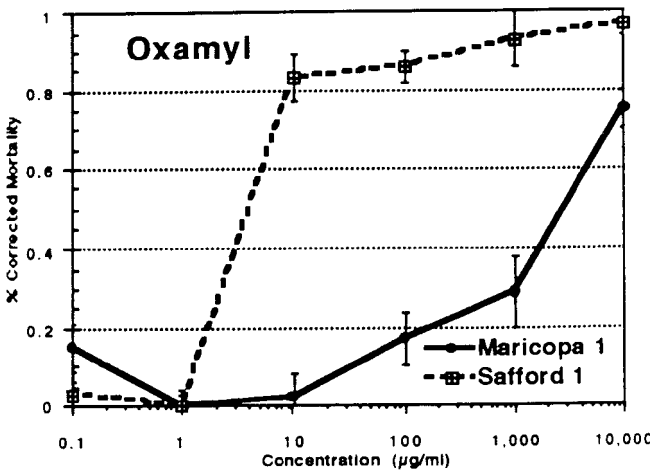

Figure 5h. Susceptibility of the Maricopa 1 and Safford 1 populations of lygus bugs to oxamyl, as depicted by mortality observed in vial bioassays.

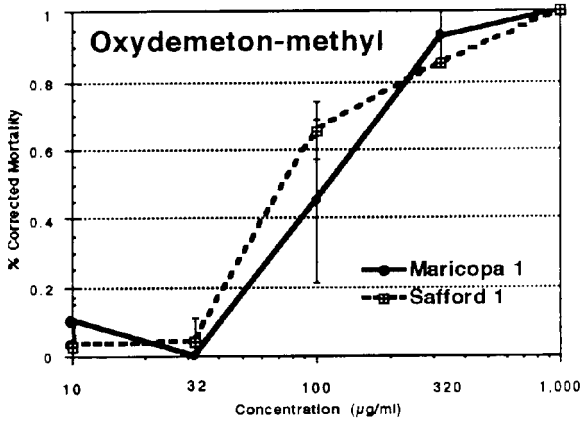

Figure 5i. Susceptibility of the Maricopa 1 and Safford 1 populations of lygus bugs to oxydemeton-methyl, as depicted by mortality observed in vial bioassays.